

Tailoring Requirements Negotiation to Sustainability

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Abstract—Requirements Engineering (RE) plays a critical role in software system development and is argued to be the key leverage point for practitioners who want to design sustainable software-intensive systems. However, existing RE methods and tools do not explicitly facilitate the discussion and negotiation of sustainability-related concerns. This leads to insufficient or one-dimensional perceptions of sustainability. In this paper, we discuss our understanding of sustainability and its relationship with requirements. Based on the outcomes of this discussion, we have extended the WinWin Negotiation Model by incorporating sustainability concepts so that the negotiation also includes the ability to consider the impact of requirements on sustainability. Applying this negotiation method in an exploratory industrial case study, we have learned that this approach stimulates the discussion on sustainability and its multiple dimensions. It also allows practitioners to reflect on requirements and their effects on sustainability. However, we have also observed that further in-depth requirements analysis is needed to analyse the long-term effects of requirements regarding sustainability.

Index Terms—Requirements Negotiation, Sustainability, WinWin Negotiation Model, EasyWinWin, Case Study.

I. INTRODUCTION

Requirements Engineering (RE) is considered the key leverage point for designing sustainable software-intensive systems [1], with a number of approaches have been proposed for modelling [2], eliciting [3], and capturing reusable knowledge [4] with regards to sustainability. However, requirements negotiation is a core activity in the requirements engineering process [5] where the needs and concerns of the various stakeholders of a software system, including those who may be affected indirectly and over a more extended period, are uncovered and negotiated [6]. While there are several negotiation approaches available, to the best of our knowledge, none of these approaches is specialised in considering the impact of a given requirement upon sustainability. While researchers suggest (e.g., [2, 3]) that current RE research approaches and methods can serve as a starting point for practitioners to integrate sustainability into their practice, none of these is currently in practical use (e.g., [7, 8]). A frequently noted reason for this is the

lack of a clear notion of sustainability in the software and requirements engineering both in academia and industry [9].

We have conducted an explorative case study to investigate how to support practitioners in negotiating requirements to understand the effects of these requirements on sustainability. To start with, we first discuss how software requirements relate to sustainability and what implication this has on the analysis and negotiation of requirements (Section 2). We then present the adaptation of an established requirements elicitation and negotiation method (EasyWinWin). The adapted method – sustainability-supportive WinWin – supports the representation and negotiation of the effects that a given requirement is perceived to have on sustainability (Section 3). This method is applied to an industrial case study, and lessons learned from this method application are discussed (Sections 4, 5 and 6). We close the paper by discussing limitations of our work (Section 7) and a conclusion also presenting ideas for a next case study (Section 8).

II. REQUIREMENTS AND SUSTAINABILITY

The concept of sustainability has emerged as an area of growing interest in the field of software and requirements engineering [10, 11, 12, 13, 14, 15, 16]; which is understood as the 'capacity' of a system 'to endure' [17]. A closely related term, sustainable development, was defined by the Brundtland Commission as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' [18]. The triple bottom line perspective of sustainability emerged to consider sustainability to include three components – environment, society and economy – which is argued leads to more sustainable outcomes [19]. This was extended to include individual [20] and technical sustainability [21]. Thus, researchers characterise sustainability against one or more of the five dimensions mentioned above: environmental, economic, social, individual and technical [1]. The environmental dimension refers to the usage and protection of natural resources. The economic dimension refers to the ability to preserve value and capital. The social dimension refers to the ability of societies to

preserve the solidarity and services. The individual dimension refers to the ability of the people to live their lives and express themselves in freedom. The technical dimension relates to the longevity of socio-technical systems. Impact on sustainability can be observed via impact on one or more of its dimensions. As a result, it is advocated that sustainability requires simultaneous consideration of these interrelated dimensions [22]. Nevertheless, interdependencies exist between these dimensions including tradeoffs that may have to be negotiated for a system under analysis [1]. In addition, we can also consider the five dimensions in relation to three orders of impacts or effects of software systems [22, 23]. Immediate effects are attributed directly to the lifecycle of the system through the resources used for its production, usage, and disposal. Enabling effects are caused by the usage of the system in its application environment, and potentially by many users over a period of time (months to a couple of years). The structural effects show when accumulating the aggregated effects of usage by many users over an extended period of time (years or decades) [24].

Consensus on what sustainability means in the field of software and requirements engineering is still emerging despite a number of attempts to formalise a definition [25, 26]. However, at least three perspectives of sustainability are commonly found in relation to the field of software and requirements engineering. The first is concerned with the principles, practices, and processes that contribute to software endurance, i.e. technical sustainability [13]. The second focuses on software systems to support one or more dimensions of sustainability [21]. The third refers to systems whose primary purpose are not related to sustainability but that have been built with consideration for its effects on the multiple dimensions of sustainability [1]. However, it is argued that the concept of sustainability requires context [27] and social structure [28]. It is suggested that rather than seeking broad conformity of definitions, the aim should be to clarify how the terms are used by different communities to have a shared understanding [29].

Given the above characteristics of sustainability, how can a requirements analyst view the impact of a given individual requirement on sustainability? This question has, so far, been somewhat unattended in RE research and practice. With the main discussion focusing on “What is a sustainability requirement?” [9]. A requirement will inevitably affect one or more of the sustainability dimensions as any given (user) requirement aims to address a need/desire to satisfy economic, personal, societal, environmental, or technical need relevant to a given stakeholder. Thus, in this work, we refrain from discussing “what a sustainability requirement is”. Instead, we take a pragmatic view, looking at what effects a given requirement will have on the economic, societal, individual, technical, or environmental well being of a stakeholder and its situated environment.

Such effects should be significant, and they may manifest themselves at different points in time given the three orders of effects relevant to sustainability. Finally, an analysis of requirements with respect to sustainability is likely to identify both positive and negative potential effects, even within a single requirement. To minimise the adverse effects of such re-

quirements possible alternatives should be identified, discussed and negotiated.

Thus, given our pragmatic view, we set out to support the requirements engineers in exploring the possible effects of requirements and the effects’ magnitudes on the different dimensions of sustainability through a requirements negotiation method.

III. RESEARCH METHODOLOGY

To observe the impacts of a given requirement on sustainability, we set out to conduct an exploratory case study investigating requirements negotiation for sustainability in a practical setting. This decision was motivated by our previous work [8], which has demonstrated that practitioners agree with the 5-dimensional representation of sustainability, yet the RE community lacks examples of situated, grounded analysis of requirements impacts on sustainability in practice. We have defined the following research questions to guide our research:

RQ1: Can a tailored requirements negotiation method considering sustainability be applied by practitioners with no or limited knowledge on sustainability-related issues?

Firstly, we are interested in finding out if practitioners with no or limited knowledge of sustainability-related issues can apply a tailored method in a real-world industrial setting themselves. This includes investigating how much training is required for practitioners to learn how to apply the method, and also how much training and knowledge is needed for practitioners to participate in the negotiation.

RQ2: Does the tailored method help practitioners to consider different sustainability dimensions and orders of effects during requirements negotiation?

Secondly, we are investigating whether practitioners will be able to negotiate requirements effects on sustainability. This includes investigating the negotiation process itself and the results of the negotiation regarding different sustainability dimensions and orders of effects.

We decided that an exploratory case study, undertaken in collaboration with practitioners, would allow us to provide answers to both of our research questions. Our study design included the following key steps.

Selection of a suitable industrial partner: For conducting our case study, we joined forces with an Austrian ERP system vendor: InsideAx who specialises in customising standard software products from a large vendor to fit individual customer needs. One of the authors had worked with this company before and knew that they were keen to investigate how the impact of customer requirements would affect sustainability, although their employees had little to no knowledge about sustainability as defined in the previous section. At InsideAx, requirements are customarily negotiated at informal workshops between the company’s consultants and its key users. We identified this requirements negotiation process as a point at which our solution would apply.

Selection and tailoring of a suitable requirements negotiation method: Given that we aim to provide a solution which would allow to analyse and maximise positive contributions to sustainability by any given requirement, we are cognizant of

the fact that the negotiated solution must be a winning outcome to all involved stakeholders. Else, the one or more of the sustainability dimensions of the losing party would be diminished. This is why the WinWin Negotiation Model [30] was considered a particularly well-suited negotiation method to adapt to our sustainability requirements analysis task.

Conduction of requirements negotiation workshops in practice: Having adapted the WinWin Negotiation Model to support negotiation of requirements impacts on sustainability, we then set out to investigate if the method could be applied in a real-world industrial setting by practitioners with no or limited knowledge on sustainability-related issues. The exploratory study was carried out with InsideAx and one of their clients. This includes a pilot requirements negotiation workshop with InsideAx employees followed by a second workshop with one of their clients.

IV. TAILORING THE WINWIN NEGOTIATION MODEL TO SUSTAINABILITY

The WinWin Negotiation Model guides success-critical stakeholders in discussing and negotiating mutually satisfactory agreements [30]. It is an integral part of the EasyWinWin [31] method, which can be applied to real-world requirements elicitation and negotiation workshops. EasyWinWin is used in software engineering education at several universities [32]. Applying EasyWinWin, stakeholders move through a step-by-step negotiation, they collect, elaborate, prioritise and negotiate requirements to come up with agreements. An EasyWinWin workshop is facilitated by a moderator and often supported with tools [31, 33]. The critical steps of EasyWinWin are:

1. Review and Expand Negotiation Topics
2. Brainstorm Stakeholder Interests
3. Converge on Win Conditions
4. Capture a Glossary of Terms
5. Prioritize Win Conditions
6. Reveal Constraints and Assumptions
7. Identify Issues and Options
8. Negotiate Agreements

A more detailed description of these steps can be found in [31]. The WinWin Negotiation Model, as shown in Figure 1, assumes that Win Conditions are describing the desired objectives of an individual stakeholder. The negotiation then focuses on the identification of issues (a conflict, risk, uncertainty on a win condition) that can be resolved with the help of one or many options (a way of overcoming an issue). Finally, this will lead to an agreement (i.e. a mutual commitment by all success-critical stakeholders to an option or Win Condition).

The underlying assumption regarding the WinWin Negotiation Model is that success-critical stakeholders have to be involved and that Win-Lose situations need to be avoided as they lead to Lose-Lose situations in the long term [31].

We consider this idea to be aligned with our understanding of how requirements should be analysed and negotiated to achieve a sustainable (WinWin) solution for all stakeholders.

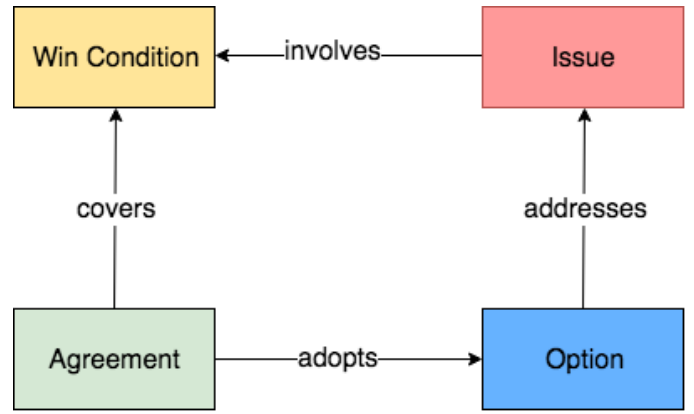


Fig. 1. WinWin Negotiation Model

This means that it is critical to involve the right stakeholders in the first place. In case success-critical stakeholders (e.g., future end-users, domain experts) affected by the system are not taking part in the elicitation and negotiation, valuable knowledge and insight needed for a fruitful discussion might be missing. As such, there is a risk that the whole negotiation could lead to software systems which have negative impacts on one or many sustainability dimensions. Furthermore, the identification of issues and options as suggested by the WinWin Negotiation Model can stimulate the investigation of sustainability effects.

These characteristics and the fact that this model is well-known in RE and applied in practice led us to select the WinWin Negotiation Model as the underlying basis for our requirements negotiation method focusing on sustainability. We extended the WinWin Negotiation Model so that it includes the ability to consider the potential effects of requirements on sustainability. As the WinWin Negotiation Model is an integral part of the EasyWinWin method, we in particular modified the steps of EasyWinWin, which represent the WinWin Negotiation Model. This includes Step 7 (Identify Issues and Options) and Step 8 (Negotiate Agreements).

Before Step 7 starts, EasyWinWin has reached the point where the moderator together with the success-critical stakeholders has derived a list of prioritised Win Conditions. An example of such a Win Condition could be: The webshop shall notify users of all new products, as shown in Table 1. Step 7 is used to negotiate these Win Conditions by identifying issues (e.g., What if users do not have an interest in these products?) that can be resolved with the help of one or many options (e.g., We send info for products the customer has declared an interest in). This will eventually lead to an agreement (e.g., The webshop shall notify users of new key products, which they have declared an interest in).

In our modified variant of step 7, it is the task of the moderator and the stakeholders to jointly identify the sustainability dimensions that are affected by the Win Condition and to investigate if it is immediate, enabling or structural effect. For simplicity, we used Excel templates to document the results of the negotiation process. An example is shown in Table 1. This illustrative example was invented by the authors when tailor-

ing and updating the WinWin Negotiation Model towards sustainability. As shown in this table, potential effects belonging to a dimension are declared with “x” or neg/pos in case the stakeholders also have a suggestion regarding the nature of the effect. For example, regarding Win Condition 1: The webshop shall notify users of all new products, we suggest that this could have a negative impact on the individual dimension as receiving many emails could annoy the webshop users. Furthermore, sending emails could have an impact on the economic dimension – it could stimulate sales because people become aware of new products, but it also could be annoying for users and therefore could lead to users unregistering from the webshop. As we are unsure if this can have a positive or negative impact, we use “x” to indicate a likely impact. This is also true for the environmental and technical dimension, where we suggest the existence of some impact using “x”. Discussing the orders of effects, we suggest that all these impacts have immediate or enabling effects. For example, energy is consumed to implement and use this mailing feature (immediate effect). Additionally, users might become annoyed shortly after we start sending out these emails (enabling effect) and economic effects might manifest after some time (enabling effect). At this stage of the discussion, to keep it simple we document our ideas with “x”, but we could also choose to add a comment on the spreadsheet to capture the rationale. Overall, this discussion should allow to understand the consequences of a Win Condition better and to stimulate the later identification of issues and options.

Following the WinWin Negotiation Model, we have identified two issues regarding the Win Condition under discussion. For example, Issue 2, which says that: What if the users do not have an interest in these products? After the identification of issues, we again start a discussion to identify affected sustainability dimensions and orders of effects. This discussion, of course, can be based on previous discussion outcomes regarding the Win Condition itself. For Issue 2 we suggest that it can have a negative impact on the individual and economic dimensions because if people are not interested in our product news, then these emails would annoy them and they may stop using our webshop. We expect that these impacts to manifest enabling effects at the individual and economic dimensions, as shown in Table 1.

For each of the identified issues, we now start a discussion regarding potential options, which can help to overcome the problems identified. For options, we recommend using a more fine-grained scale for discussion (e.g., very negative effect -5 to very positive effect +5) to highlight the consequences of this option regarding the different effects and dimensions. This discussion is the basis for Step 8 and should allow for the identification of the most promising option(s), which then can be proposed as an agreement. This agreement is used to define a formalised requirement.

There can be several options identified for one issue, but for Issue 2 we only have one option: We send info for products the customer has declared an interest in. This option might have a positive impact on the individual dimension because if the emails present valuable information for the

users, then they would not be considered to be annoying and the users actually might want to read them. In the selected scale from -5 to +5, we chose to describe this effect as a “3” since the information the user will receive is likely to be of their interest, but not guaranteed (which would be a “5”). Following similar rationales, we also consider this option to have a moderate positive effect on the economic dimension which is indicated by “2” in the example. For this option, we do not need an in-depth discussion of the orders of effects as we considered them to be the same as for the related issue (Issue 2). For options regarding Issue 1, e.g. Option 1, we can still identify negative impacts: Implementing a feature for sending out emails that can make the technical solution more complex (-1 for the technical dimension), which also may have a negative impact on the environment, as many emails will still be sent out (-1 for the environment dimension). It is also interesting to note that by providing options, one might be causing effects in dimensions that were not perceived as being initially affected by a given issue. For example, Issue 2 and its Option 1. Issue 2 is only perceived to affect the individual dimension, but the Option 1 (which refers to the implementation of functionality for the user to indicate its preferences) will have effects on the technical and the environmental dimensions, due to maintainability and energy consumption issues respectively.

This negotiation of issues and options and the of analysis of effects on sustainability is the basis for making an informed decision about this Win Condition. In our case, we assume that the stakeholders still want to keep this requirement, but they consider the outcomes of the discussion and modify the original Win Condition in a way that negative impacts regarding all dimensions are minimised. The outcome is Agreement 1, a requirement which says: The webshop shall notify users of new key products they have declared an interest in.

In summary, our tailored WinWin Negotiation Model embedded in the EasyWinWin method investigates which of the gathered requirements are likely to affect (some of) the five sustainability dimensions, as well as their order of effects. This discussion is based on the knowledge and insights of the participating stakeholders. Therefore, it is essential to include all success, critical stakeholders, but even then, the discussion is based on assumptions as highlighted in the presented example. We also aimed to create a lightweight method that can easily be applied by requirements engineers who have not received formal education or training regarding sustainability.

V. APPLYING EASYWINWIN IN PRACTICE

InsideAx and one of their clients applied the method in a requirements negotiation workshop. Our goal was to investigate if the technique could be implemented in a real-world industrial setting by practitioners (RQ1) and to investigate if practitioners consider different sustainability dimensions and orders of effects during requirements negotiation (RQ2). To do so, we followed a two-step process. First, we conducted a pilot workshop to introduce the method to two ERP consultants in the InsideAx company, who had no previous experience in discussing sustainability issues. Second, we conducted a re-

TABLE I. A NEGOTIATION EXAMPLE INVENTED DURING METHOD CREATION

Identify Issues, Options and Agreements		Sustainability Dimensions					Orders of Effects		
Identifier	Description	Individ.	Social	Economic	Environ.	Technical	Immediate	Enabling	Structural
Win Condition 1	The webshop shall notify user of all new products	neg		x	x	x	x	x	
Issue 1	If too many notifications are sent this could lead to spam	neg		neg	neg	neg	Environ.	Individ. Economic Technical	
Issue 2	What if the users do not have an interest in these products?	neg		neg				Individual Economic	
Option 1 for Issue 1	There is a maximum number of messages sent to a customer per a predefined period of time	1		1	-1	-1	Environ.	Individ. Economic Technical	
Option 2 for Issue 1	Messages are only sent for highly attractive products	2		2	-1	-1	Environ.	Individ. Economic Technical	
Option 1 for Issue 2	We just send info for products the customer has declared interest	3		2	-1	-1		Individ. Economic Technical	
Agreement for Win Condition 1	The webshop shall notify user of new key products which they have declared an interest in.								

quirements negotiation workshop with one of their clients in Austria. This workshop was held at the client's site involving the two consultants from InsideAx, the CEO of the client company, and two of the academic authors of this paper.

A. Pilot Workshop

A 2-hour pilot workshop was held the day before the actual customer workshop. After an introduction of the five sustainability dimensions and orders of effects (approx. 15 min.), we discussed the EasyWinWin method, where we focused on the modified Steps 7 and 8 and introduced the Excel template (approx. 20 min.). One of the academic researchers did these first steps. Then we started with the actual requirements elicitation and negotiation. However, the focus was on the actual negotiation, and the other EasyWinWin steps were briefly walked through. This was also possible because InsideAx had already prepared a list of requirements (Win Conditions) for a more in-depth discussion regarding sustainability. In this pilot workshop, one of the consultants already acted as moderator (and as the business analyst), and the other one played the role of an ERP customer (and the technical expert). The two participating academic researchers observed the workshop and served as scribes; they also had the opportunity to get involved in the discussion to clarify open issues regarding the approach, the sustainability dimensions, and the orders of effects. The academic researchers made minor adaptations of the Excel template created for documenting the process outcomes based on the lessons learned during the pilot. Finally, the workshop ended with a wrap-up session (approx. 15 min.) where the results of the pilot were discussed.

B. Requirements Negotiation Workshop with an ERP Customer

The actual elicitation and negotiation workshop was held at the customer site and took 4,5 hours (including a tour through the facilities). In addition to a customer representative (the

CEO), the two consultants from InsideAx and the two academic researchers, who had participated in the pilot workshop, also participated in this on-site workshop. While the first consultant again acted as moderator, the second consultant had the role of a technical expert answering technical and ERP system related questions. One of the academic researchers served as scribe for the workshop, while the other observed the workshop from the method and research perspective, and also documented outcomes in this regard. However, the academic researchers were also allowed to contribute to the discussion. During the workshop, the template and documentation of the scribe were visible to all participants. Again, the workshop ended with a short wrap-up session (approx. 10 min.) where all participants were asked to communicate their impression of the workshop. The workshop was audio recorded and later transcribed for analysis. Before the workshop, we conducted a stakeholder analysis to identify success-critical stakeholders and also reviewed and discussed negotiation topics (Step 1).

The stakeholder analysis was performed by the two ERP consultants and the academic researchers. It was strongly based on the stakeholder analysis done by InsideAx for previous workshops with this client and done in an informal way with the help of brainstorming. The analysis revealed two success-critical stakeholders: (1) a domain and process expert who knows about requirements for the evolution of the ERP system and (2) a technical expert who knows the capabilities and constraints of the ERP system in use. Furthermore, the involvement of employees performing the process and other stakeholders from the supply chain were also considered. However, due to the limited time and resource available for the workshop, it was agreed to focus on the company's CEO, who is a domain and process expert, and the one consultant from InsideAx who is a technical expert.

For reviewing and expanding the negotiation topics, the ERP consultants and the customer agreed to an upfront discus-

TABLE II. OUTCOME OF THE PILOT WORKSHOP

Identify Issues, Options and Agreements		Sustainability Dimensions					Orders of Effects		
Identifier	Description	Individ.	Social	Economic	Environ.	Technical	Immediate	Enabling	Structural
Win Condition 3	Employees can use a Smartphone to document and communicate that new articles have been produced, so that the stock is accurate.		x	x	x	x			
Issue 1	Employees need a Smartphone			neg	neg				
Issue 2	Envy of employees who do not get a Smartphone	neg	neg				Individual	Social	
Issue 3	Additional work for employees	neg		pos					
Issue 4	Wi-Fi problems	neg		neg		neg			
Option 1 for Issue 1	All employees get a Smartphone	2	1	-2	-2	-2	Individual, Economic, Environ., Technical	Social, Technical	
Option 2 for Issue 1	Only "relevant" employees get a Smartphone they are allowed to use at home	2	-2	-1	-1	-1	x		x
Option 3 for Issue 1	Only "relevant" employees get an "ugly" Smartphone, which they are not allowed to use for private purposes	-1	0	-1	-1	-1			
Option 4 for Issue 1	A Smartphone next to every production machine to be used as scanner	0	0	-2	-0.5	1			
...									
Agreement for Win Condition 3	Employees can use a Smartphone, which is available next to every production machine, to communicate that new articles have been produced, so that the stock is accurate.								

sion that the workshop would focus on ideas regarding ERP system evolution.

As the goal of the workshop was the negotiation of requirements regarding their impact on sustainability, we decided to apply the EasyWinWin method in a way which allowed us to reach the negotiation part (Step 7 and 8) in a rather short time.

We started the workshop with a short presentation motivating the need for negotiating sustainability issues, explaining the five dimensions and the three orders of effect (approx. 10 min.). Furthermore, we introduced the EasyWinWin method (including our adaptations) and presented a short agenda (approx. 15 min.). After the opening, we started with step (2) Brainstorm stakeholder interests; The goal of the brainstorming session was to identify ideas for system evolution. We kept the brainstorming step relatively short (approx. 20 min.), as we intended to focus on the later discussion of sustainability issues. The customer had a clear vision of how to evolve the system, which supported the short brainstorming session and led to the identification of 12 ideas.

In the next step (3) Converge on Win Conditions, all 12 ideas were refined and transcribed into Win Conditions. We did not apply Step (4) Capture a glossary of terms, as the terms used were apparent to the audience, and because of time constraints. In the following, the defined Win Conditions were prioritised (Step (5) Prioritize Win Conditions) by the customer with regards to their business importance. The technical expert communicated the technical feasibility of the Win Conditions, but we restrained from in-depth prioritisation regarding feasibility due to time constraints. This means that only the customer was prioritising requirements and therefore we could skip step (6) Reveal Constraints and Assumptions, which would

have allowed us to identify, reflect upon, and reveal conflicts and mismatching perceptions among different stakeholders.

The results of the prioritisation revealed 3 Win Conditions of high priority, which were negotiated in the next step, (7) Identify Issues and Options. For all identified issues, the affected sustainability dimensions were discussed and documented. The identification and discussion of the options included identifying the possible effects and their magnitude (very negative effect -5 to very positive effect +5) for each of the dimensions. The method allowed a discussion about the effects, but identifying the orders of effect (immediate, enabling, structural) is challenging and did not always take place, also due to time constraints and a lack of knowledge. Finally, the workshop participants formulated agreements (Step 8).

C. Example Result

As the customer of InsideAx wanted to remain anonymous, we did not discuss the results of the workshop at the customer site. Instead, Table 2 presents a Win Condition negotiated in the pilot workshop with InsideAx as an example. Please note that this example is very similar to the examples discussed within the actual workshop.

The example Win Condition is "Employees can use a Smartphone to document and communicate that new articles have been produced so that the stock is accurate." (see Table 2). This is an essential and exemplary feature of the customer domain as the ERP production statistics need to be up-to-date and just in time scheduling for some calculations regarding the overall production time for specific orders. The discussion of issues and options of the Win Conditions have been simplified to minimise complexity and enhance understanding.

Discussing the Win Condition regarding the different sustainability dimensions in the pilot workshop at InsideAx, the business analyst (who acted as moderator) and the technical expert (who acted as ERP client), concluded that it had an effect on four sustainability dimensions: more accurate statistics (economic); just in time scheduling (economic); the change in the ERP system (technical); and the provision of a smartphone to the employees (environmental, social). Please note that in this step, the individual dimension was not marked as affected yet. Later on, when starting the discussion on the issues, the individual dimension gained much more attention and was considered as very much affected.

The two consultants from InsideAx identified four issues regarding the Win Condition under discussion. Next, to the technical issue (that Wi-Fi problems might occur when using Smartphones to communicate stock numbers just-in-time), three issues focusing on the employees (and their feelings) have been identified. The first one concerns the “additional amount of work” that the employees have to do when this feature is implemented, and the other two are about the problem that the employees need to get a smartphone to do the work that might result in “envy” of employees who do not get a smartphone.

Analysing the impact of these issues on sustainability, the two consultants made the following findings. The additional work for the employees leads to an adverse effect on the individual and a positive one on the economic dimension as the statistics are now up-to-date. The issue regarding the Wi-Fi problems leads to a negative impact on the individual, the economic and the technical dimension. They assumed a negative impact on the individual dimension because Wi-Fi problems could lead to annoyance and cause extra work. The issue regarding “employees need a Smartphone” has an adverse effect on the economic dimension (it costs a reasonable amount of money to provide every staff member with a smartphone and a contract) and the environmental dimension (e-waste). The most discussed issue was the one regarding envy of the stakeholders who do not get a smartphone. This more extended discussion revolved around the possible individual and social effects caused by this issue. Based on this discussion possible immediate and enabling effects have been identified. The discussion revealed that the economic and individual dimension is possibly directly negatively affected because there will be a grudge and malevolence among the different employees (the one getting a smartphone and the one without). In addition, an enabling negative social effect might occur through erosion of trust.

Next, the options were discussed. In this example, the most pressing issue was Issue 1: “Employees need a Smartphone”, so this was the issue, which was considered for identifying and discussing options. Please note, that ideally options would be discussed for all issues (as shown in our first example – see Table 1). In the pilot workshop, the discussion was stopped after identifying options for Issue 1, also due to time constraints. However, the consultants from InsideAx still were able to come up with an agreement.

The consultants from InsideAx were able to identify options for Issue 1. For example, Option 1 “All employees get a Smartphone” was rated between -2 and 0 for the different dimensions. It got a positive rating for the individual (+2) and social (+1) dimension as with this option all employees are treated equally and also everyone is happy receiving a smartphone. The economic, environmental and technical dimensions are all rated negative (-2) as the technical and financial expenditure is high, as well as the e-waste, in comparison to the other options. For this option, the immediate, enabling and systemic effects have been discussed and identified during the workshop. The consultants from InsideAx named four immediate (individual, economic, environmental, technical) and two enabling (social, technical) effects. The immediate effects all are directly coupled with the fact that every employee gets a smartphone: the employees receive it and are most likely happy to have a company phone (individual), this, however, is cost intensive (economic), e-waste will be produced (environmental), and the technical effort to integrate all smartphones into the ERP system is high (technical). The enabling effect is the higher technical effort to enable communication via Wi-Fi for an increased number of equipment (technical). As all employees are treated equally, and everyone gets a similar company phone, this should contribute to establishing a community feeling and better working atmosphere (social).

Interestingly, in the given example, most of the discussion about the different options (shown in Table 2) evolved around the social dimension of sustainability. A debate took place about the possible erosion of trust if only selected employees would receive a smartphone (to register products as soon as they are produced), and how this may affect the team spirit and, on the long run, the social cohesion within the company.

There were three more options, which were discussed in the workshop, which are shown in Table 2. However, here the consultants from InsideAx did not go into so much detail and neglected the discussion of orders of effects. The one option which in the end has a significant influence on the agreement was: “A Smartphone next to every production machine to be used as scanner”.

In Step 8 the consultants from InsideAx agreed on using one Smartphone per machine to scan newly produced articles (“Employees can use a Smartphone, which is available next to every production machine, to communicate that new articles have been produced, so that the stock is accurate.”). This agreement was made to avoid any issue from handing out Smartphones to employees and because it had the best impact on the technical dimension (least technical effort, only one piece of hardware to integrate for each machine) from the suggested options.

VI. REFLECTIONS AND LESSONS LEARNED

The application of the tailored WinWin Negotiation Model embedded in the EasyWinWin method in a real-world setting led to several lessons learned and allowed us to provide first answers to our research questions.

On the positive side, this first trial of the method applied in two workshops – first with the consultants and then with the customer – worked well and can be considered a successful feasibility study. This means that the workshop was conducted by practitioners, who initially had limited to no knowledge about sustainability and resulted in the identification of issues and options and a discussion of their effects classified accordingly to the sustainability dimensions. Furthermore, in the debriefing, after the second workshop, the customer feedback was positive as the customer considered the outcome as valuable for the evolution of his company’s ERP system. He even asked us: “When are you coming again – how do we continue?”. The consultant from InsideAx acting as the moderator in both workshops also declared himself satisfied with the application of the negotiation process and the outcome of the workshop and communicated his willingness to apply the method again independently. In fact, he was able to use the technique without methodological input from the academic researchers, already in the second workshop.

Overall, we needed much less time for the explanation of sustainability than we thought. Within the pilot workshop, we were able to make the employees of InsideAx understand the sustainability dimensions and orders of effects within about 15 minutes. For the workshop with the customer, we needed only 10 minutes to make the CEO understand these concepts. Likewise, the InsideAx employee, who had experience with requirements negotiations, but not EasyWinWin, was able to understand the method with limited training effort (approx. 20 min.).

With the help of these results from our case study, we can tentatively answer our first research question with a yes; practitioners were able to apply our tailored EasyWinWin method without the help of academic researchers and only needed limited explanation and training to do so.

In general, the sustainability dimensions were understood and helpful to both the consultants and the customer. They were able to identify affected dimensions for the requirements under discussion and to propose alternative requirements with a smaller negative impact. However, we also came across a number of difficulties. The discussion on the effects of requirements was often based on uncertainty and a lack of information to anticipate compounded long-term effects, which lead to participants having different opinions on the effects and their magnitude. To resolve these issues, information that was not available during the workshop and which needed to take into consideration the opinion of further stakeholders is required. Additionally, it may be possible that the participants had different understandings of the orders of effect. Therefore, a focused discussion on the order of effects was not viable. However, during the workshop, it was possible to identify some of the immediate and enabling effects, but not the structural ones.

When discussing effects, we noted that there is a risk to overlook stakeholders that are affected by the proposed solution and may jeopardise the project later on (e.g., some people like the idea of having a corporate phone, others hate it, and some may have privacy issues). A possible solution would be to nominate sustainability representatives, who can act as a

surrogate for the sustainability concerns of stakeholders. However, this person would need to have in-depth domain knowledge in addition to knowledge about sustainability design.

We also observed that the in-depth discussion on effects takes up a lot of time at the workshops. For this, we suggest that an analysis step needs to follow the workshop, to adequately analyse and decide on the most agreeable alternative from those noted during the workshop, when in doubt. Moreover, extra time would often be necessary for gathering additional information, which is not feasible during the actual workshop.

Another direction for future improvement of the method is to use system dynamics models to help visualise, analyse, and understand the balancing and reinforcing feedback loops and their effects within a specific problem domain [16]. Overall, improved visualisation of effects instead of merely using Excel can be an interesting investigation for next case studies.

It is worth noting that the ideas and options identified influenced each other. We have learned that the best option to solve one problem might become even more convincing when other problems can also be addressed with it as well. For example, providing each member of the staff with a mobile phone is an option that can be used for solving the Win Condition of being able to report the status of the production in real time as well as reporting details on materials.

Finally, we experienced that during the workshop, discussions often revolved around the nature of the effects of the requirements on the sustainability dimensions (e.g. positive vs negative, short-term vs long-term, direct vs compounded). The workshop participants discovered every discussed requirement having a possible effect can be classified as belonging to on one or more sustainability dimensions. Thus, all considered requirements affect sustainability. This strongly supports our argument that all requirements need to be considered and analysed for their impact on sustainability.

Regarding RQ2, the preliminary evidence suggests that while the method enables practitioners to negotiate requirements effects on sustainability, there is scope for improvement. This is particularly true for the discussion of orders of effects as the application of the method did not result in the discussion of cumulative long-term sustainability-related effects of a given requirement.

VII. LIMITATIONS OF OUR WORK

This paper presents an explorative study on the WinWin Negotiation Model embedded in the EasyWinWin method for a requirements negotiation that considers the effects of a given requirement on sustainability. Conducting our first exploratory case study, we have also identified several limitations of our work and open questions which we plan to address in future case studies with companies.

Although EasyWinWin is a group elicitation and negotiation method, due to time and cost constraints, we only involved one representative stakeholder from the customer side (the CEO) and two ERP experts (one technical expert and one business analyst who served as moderator). The decision to keep the set of participants limited was made in discussion with the

ERP consultants: it was decided that involving more stakeholders, especially when the method was being applied for the first time, would be too costly. Nevertheless, since the customer representative was a domain and process expert, he could serve as a surrogate representative for other stakeholders such as employees. However, we are well aware that by not inviting additional stakeholders, such as employees working in the production, we might have missed out on the opportunity of capturing a more comprehensive set of viewpoints. Thus, the impacts on sustainability identified in our study are likely to be the minimal set of relevant ones. Also, by doing so, we are also contradicting our idea to involve all success-critical stakeholders in the negotiation. This is a relevant threat to the external validity of the present study: the prior experience of the involved stakeholders could have biased the findings reported above, despite the fact that this study does not claim any generalisability. As a result, in future studies, we need to involve a broader range of key stakeholders in order to investigate the effects of having different viewpoints included in the negotiation, as well as investigating the scalability of the negotiation method.

The limited time allocated to the workshop also precluded a detailed discussion on many topics, as noted in the case study section. This again is likely to have resulted in the loss of potentially valuable information. Furthermore, the familiarity (or lack of it) that the participants had with the technique used for requirements negotiation was not monitored and (given the small scope of the study) is not controlled, which is also a consideration for the external validity of this and further studies in the application of the proposed technique. Nevertheless, we find the conclusions obtained from the present study to be relevant and encouraging, even given the limited stakeholder participation and time factors. This suggests that for future studies we also need to plan for more extended workshops sessions to allow for a more detailed discussion and the inclusion of more key stakeholders.

Another limitation (and a threat to external validity) is that the proposed method is based on specific sustainability-related concepts (i.e., dimensions and effects). This study alone is not sufficient for either confirming or refuting the proposition that considering these concepts is enough for allowing a detailed discussion of the impact of requirements on the holistic sustainability concern. We build our tailored EasyWinWin method on the well known and accepted concepts of the five sustainability dimensions [21, 22] and the three levels of effects [24]. However, there may be other concepts relevant to sustainability which this exploratory study did not consider. Furthermore, we have observed that the impact of requirements regarding structural effects is currently not well supported. Investigating the reasons for this will require additional research and more practical case studies.

It should also be noted that the prior understanding of sustainability by the study participants could be a compounding factor in the requirements impact identification and analysis, thus threatening the internal validity of the study. To accommodate for this, we have carried out a pilot stage of the study, during which the notions of sustainability and the relevance of

its dimensions and orders of impact were explained. The significance of these notions was also re-iterated through the templates suggested for impact negotiation. In short, we do not make any claims that the results presented in this paper are either generalisable or entirely reliable; instead, we note these are relevant and promising as a new direction of studying the impact of requirements on the sustainability concern.

Concerning the results of the negotiation, we observed that the stakeholders made excellent use of the sustainability dimensions and immediate impacts. However, only a few long-term impact effects were analysed. There can be two main reasons for the limited number of such effects. Either the stakeholders were not able to identify the long-term effects due to the limitations of the study set up, or the used method (e.g., not all key stakeholders were invited, the time available for the workshop was short, information to support analysis was not available, etc.) or the stakeholders were not interested or able to consider the long-term timescale. The difficulty of considering the long-term timescale in software-related decision making is documented in other related research [34].

VIII. CONCLUSION AND FUTURE WORK

The recognition of sustainability in the design of today's systems requires that this new concern is addressed efficiently during requirements negotiation. The complex nature of how sustainability manifests across technical, economic, social, environmental and human issues, and the degree to which these impacts manifest across time, requires that any method used to negotiate requirements should directly consider sustainability from the start. It should also be grounded in requirements engineering practice if it is to be practicable by the general requirements engineering practitioners.

This paper presented a modified WinWin Negotiation Model and the EasyWinWin method to support the negotiation of requirements and their impact on sustainability. This includes identifying affected sustainability dimensions, discussing how immediate, enabling and structural effects are manifested, and how these effects should be taken into account in the development of a system.

The results of applying this method in an exploratory case study suggest that practitioners can apply the proposed approach in real-world settings (RQ1) and that it was perceived as a useful technique supporting the negotiation of requirements to consider different sustainability dimensions (RQ2). However, we also identified limitations regarding the discussion of orders of effects (RQ2). Overall, our case study has led to a number of fresh insights. In particular, it supports our view that every requirement affects sustainability and each such effect should be considered if the full view of the software system's impact on sustainability is to be observed.

Despite the fact that we so far were not able to find a quick way for analysing cumulative long-term sustainability-related effects of a given requirement with our proposed analysis approach, we believe the present study demonstrates that we need to be able to analyse the impact of each requirement on sustainability systematically.

We plan to conduct further empirical studies to apply the presented negotiation method in diverse settings to further validate the initial findings and answer open questions. In particular, we are planning a series of case studies, which will help us to answer questions which came up as a result of this initial study presented in this paper. This will include investigating: a) How the method performs when a larger number of stakeholders is involved; b) How to stimulate a negotiation and discussion of long-term effects; c) How to visualise the outcomes of the negotiation, and d) How scalable our method is when used for large-scale negotiation. As a result of this study, we are of the opinion that this work will further support the integration of sustainability concerns into software engineering practice.

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